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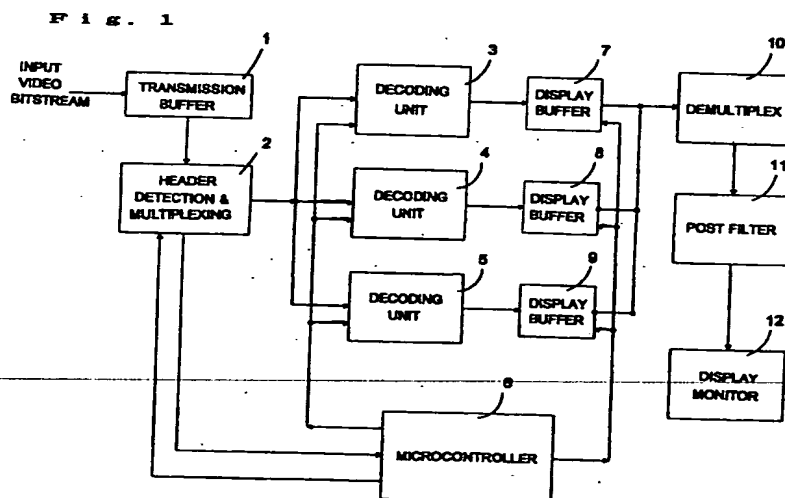
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(54) Management of multiple buffers and video decoders in progressive digital video decoder

(57) A progressive (non-interlaced) video decoding system has : memory for input transmission buffering a video bitstream received from a transmission channel; transferring device , coupled to said input transmission buffering means, for multiplexing and transferring the said video bitstream to the multiple video decoders; controller, coupled to said means for multiplexing and

transferring, for controlling the decoding process of each of the multiple video decoders; and demultiplexer , coupled to said means for controlling the decoding, for controlling the display buffers of each of the multiple video decoders and de-multiplexing the display output of each of the said display buffers.



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## Description

## BACKGROUND OF THE INVENTION

## 1. Field of the Invention

The present invention relates to a compressed video decoding apparatus which is capable of decoding video bitstream containing progressive (non-interlaced) pictures which is different from the existing interlace pictures in television system.

## 2. Related art of the Invention

The current existing television systems in the world are NTSC, PAL and SECAM. All this systems are interlace display systems which can be annoying at times and also weakens the human eyes. Some manufacturers had tried to resolve this by using double line scan. In double line scan, each line of the picture is scan twice to produce a flicker free output. However, this only solves half the problem. This is because the artifacts such as 'steps' appear at the edge of pictures, giving the appearance that the picture is blocky. During the last few years, there had been attempts by some broadcasters and manufacturers to rectify these problems by proposing a new television standard called the High Definition Television Standard (HDTV). However, high costs and complexity in both the receiver and broadcasting equipment discourage most consumers and broadcasters. As a result wide acceptance in the real world had not been very successful.

Recently, the Moving Pictures Expert Group (MPEG) had defined a new video compression called the MPEG2 which is capable of compressing pictures upto 200 times and therefore open the path for digital broadcasting. However, MPEG2 video compression chips that were delivered as a result of this standard mostly use only Main Profile at Main Level (MP@ML) and display the standard interlace output. This therefore does not completely solve the problems mentioned above as there is no improvement in either picture resolution nor display rate.

Current existing standard systems can only display interlace output. This type of flickering display can be rather annoying to users and damaging to the eyes. In addition the resolution is low and interfacing to computer graphics which is generally of high resolutions is unsatisfactory. Current analog transmission system is also lower in quality and reliability compared with digital transmission. However, digital transmission bandwidth requirement is enormous and some compression is required. HDTV systems which can solve most of the above problems cost too high both for broadcasters and consumers.

## SUMMARY OF THE INVENTION

A system had been invented which is capable of decoding progressive video bitstream compressed according to the MPEG2 standard. The system is capable of displaying progressive pictures flicker free and with little artifacts. The system also provide a higher resolution compared to existing standard system. In addition, interfacing to and displaying computer graphics is easier and results in higher quality output. More importantly, it is expected to cost much less than a HDTV system, both for broadcasters and consumers.

That is a system had been invented which is capable of decoding progressive video bitstream compressed according to the a MPEG2 standard. The system is capable of displaying at a progressive output of 60Hz for NTSC system with a resolution of 720X480 per frame of picture. With the number of horizontal scanning lines increased per vertical scan, the pictures appear sharper than interlace. More importantly, the pictures are now flicker free with no drop in picture quality. In addition, interfacing to computer images and graphics can be done more easily as most computer images are non-interlaced and those annoying single line flicker is removed.

Estimated cost of the progressive decoding system is about only 10-15% of the current high end television system. Broadcasting equipment for a progressive decoding system is also expected to only cost about 10-15% more than current broadcasting equipment. This is significantly lower than HDTV which currently can easily cost twice as much more for either receiver or transmitter.

For the purpose of solving the above-described problems, a progressive video MPEG2 decoder according to the present invention comprises means for input transmission buffering a video bitstream to the multiple video decoders, means for controlling the decoding process of each of the multiple video decoders and means for controlling the display buffers of each of the multiple video decoders and de-multiplexing the display output of each of the said display buffers.

By the above described configuration, the present invention is a system that is capable of receiving MPEG2 compressed progressive video bitstream from a transmission channel, decoding and reconstructing the pictures from the said video bitstream, transferring the reconstructed pictures into display buffers and finally output the display buffers pictures into a progressive monitor. The present invention can be used either as a broadcast decoder receiver or as the

decoder in a disc system.

## BRIEF DESCRIPTION OF THE DRAWINGS

- 5 Figure 1 is a block diagram of a novel buffers and interlace video decoder management scheme in one embodiment according to the present invention,  
 Figure 2 is a block diagram showing one example of the internal arrangement of the decoding units in Figure 1,  
 Figure 3 illustrates the picture type and display order in typical sequence of display,  
 Figure 4 illustrates the picture type and display order in a encoded video bitstream corresponding to the display  
 10 order shown in Figure 3, and  
 Figure 5 shows the flow diagram of the micro-controller processes in the management scheme of buffers and interlace video decoders for a progressive video decoder system in one embodiment according to the present invention.

## PREFERRED EMBODIMENTS

- 15 With reference to the drawings, a brief explanation on MPEG2 syntax and bitstream will be explained hereinafter. The MPEG2 bitstream has video syntax which corresponds to a hierarchical structure. A "sequence" is the top layer of the video coding hierarchy and consists of a header and some "Group Of Pictures" (GOPs). The sequence header initializes a decoder. A GOP consists of a header and a number of pictures. Each GOP usually has one I-pictures, some  
 20 B-pictures and some P-picture. The I-picture, B-picture and p-picture also have header codes indicating picture type. I-pictures are intra-coded, i.e., they are compressed using only information from within the picture itself. P-pictures are coded from a previous P-picture or I-picture and from within the picture itself. B-pictures are bidirectionally-coded pictures, which means that B-pictures are coded from previous I-picture or P-picture and from the future P-picture. Because of picture dependencies, the pictures in the compressed video bitstream is not in display order. For example,  
 25 as shown in Figure 3 is the normal display order of a group of pictures. Comparing this with the picture order as shown in a video bitstream in Figure 4, it is shown that the B-pictures is dependent on I-picture or P-picture and therefore I-picture and P-picture must be transmitted and decoded before the B-picture.

- The operation of each of the decoding unit 3,4,5 as shown in Figure 1 and Figure 2 will be explained hereinafter. Each decoding unit 3,4,5 requires one GOP of pictures plus the first four pictures from the next GOP. The reason is due  
 30 to the fact that each of the decoding unit operate in a pipeline manner but independent of each other. To further explain the reason, observe what had been explained earlier in the video syntax of MPEG, where I-picture and P-picture must always precede the B-picture. However, in the normal GOP other than the first GOP of a sequence, the picture order in the bitstream is usually in the order below.

35

Previous GOP	current GOP	next GOP
IBBPBBPBBP.....	IBBPBBPBBP.....	IBBPBBPBBP

- 40 Hence the first two B frames of the current GOP to be decoded by the decoder unit, example, 4, must be removed. However, this cause a loss of two frames which is unacceptable. To rectify this, the decoder unit 3 that decodes the GOP preceding the current GOP will decode the IBBP pictures of the current GOP while decoding unit 4 will decode the IBBP of the next GOP. Therefore, no pictures are lost and each decoding unit 3,4,5 remains independent.

- 45 With reference to the drawings in Figure 1 and Figure 2, an embodiment of the management of the buffers and video decoders will be explained hereinafter. Whenever an input video bitstream is received from a transmission channel, the transmission buffer 1 will buffer the bitstream until the header detection unit 2 is ready to process the bitstream. The header detection reads the bitstream from the transmission buffer 1 at a rate that is much faster than the input rate  
 50 into the transmission buffer 1. This ensures that the transmission buffer will not overflow. The header detection 2 has a comparator to compare the input bitstream with the required header to be detected, which is provided by the micro-controller 6. The micro-controller 6 controls the header detection 2 by loading the header code to be detected into the comparator. By loading the header code to be detected, the micro-controller 6 can detect the start and end of a GOP and also the picture type in the video bitstream coming from the transmission channel. Therefore, the micro-controller 6 is  
 55 able to cut up the bitstream into three portions as shown in Figure 1 and controls multiplexer 2 which multiplexes and feeds the video bitstream into the independent decoder units 3,4,5 as shown.

Figure 2 shows the internal block diagram of the decoding units 3,4,5. When decoding units 3,4,5 receives the multiplexed video bitstream from the multiplexer 2, the bitstream is stored in the multiplexed buffer 13 of each of the decod-

ing units 3,4,5 as shown in Figure 2. The decoding units 3,4,5 then wait for the start signal from the micro-controller 6 to activate the interlace video decoder 14 and hence the decoding process. The micro-controller 6 activates the interlace video decoder 14 when the multiplexed buffer 13 has enough bitstream data for the decoding process. During the decoding process, the interlace video decoder 14 reads the bitstream from the multiplexed buffer and outputs the reconstructed pictures into the respective display buffer 7,8,9 connecting independently to each of the decoding units 3,4,5. the interlace video decoder 14 stops decoding when the multiplexed buffer 13 is almost empty. Usually this also indicates that one GOP of bitstream has been read out from the multiplexed buffer 13 and had been decoded by the interlace video decoder 14. Once the interlace video decoder 14 stops decoding, it can be activated again only by the micro-controller 6. Therefore the micro-controller 6 can control the decoding period and sequence of the decoding units 4,5,6 in a pipeline manner and thus ensure that the input bitstream is decoded in synchronization with the bit rate, i.e., no underflow or overflow will occur.

The micro-controller 6 controls the output of the display buffers 7,8,9. At anytime, only one of the display buffers 7,8,9 will be selected for reconstructed picture output to be sent to the de-multiplex unit 10. The display buffers 7,8,9 will be rotational selected by the micro-controller 6 to ensure a seamless output at the display monitor 12. The post filter 11 interpolates the chrominance video data to generate a 720X480 display output. Because of the post filtering, some buffering at the post filter 11 is required to delay for the luminance reconstructed video data. The reconstructed and post filtered picture data is then synchronized with the video sync and finally converted to analog for display on the display monitor 12.

Figure 5 shows the flow diagram of the micro-controller 6 processes in the management scheme of buffers and interlace video decoders for a progressive video decoder system. Starting from typical process flow in the micro-controller 6 at 15, where the header detection unit 2 checks for the GOP header. For simplification purpose and prevent repetitive drawings, the typical decoding unit is labeled as X.

this is because the micro-controller 6 will rotate the controls through all the decoding units 3,4,5 and the operations are the same. Once the GOP header is detected, the decoding unit(X-1) which had bitstream written to it previously is activated(step 16). At the same time, as in step 17 the decoding unit (X) which has just completed decoding will have its multiplexed buffer 13 enable for bitstream input. Also, as in step 18, display buffer connected to decoding unit (X) is enable and the data read out to the de-multiplexer 10. The control process then repeat itself but the decoding unit affected is (X) as in step 20, and (X+1) as in steps 21 and 22.

As mentioned above the present invention for a progressive video decoder enables multiple interlace video decoders to run in a pipeline manner to achieve the bandwidth and timing required to decode progressive video bitstream received from a transmission channel and display as a non-interlace flicker free video output. Input video bitstream upto 100M bits/s can be received by this buffering and control management technique. The GOP headers in the received video bitstream is tagged and the subsequent bitstream following the GOP headers is then multiplexed to the interlace video decoders which are running in a pipeline manner. Picture decoding, reconstructing, and display operations are synchronized to permit the transfer of data from the input buffer to the interlace video decoders and from the interlace video decoders to the display buffers seamlessly, and without causing either underflow or overflow problems in any of the interlace video decoders. A micro-controller regulates and controls the operation of data transfers, intensive and high speed processing, video decoders activity and synchronizing in the progressive decoder system. As apparent from the above described explanation, by a novel management of buffers and interlace video decoders, a MPEG2 video decoding receiver, that can decode at more than twice processing power than that of a normal interlace MPEG2 decoder and therefore capable of decoding progressive video bitstream and displaying on a progressive video monitor is invented.

## Claims

1. A progressive (non-interlaced) video decoding system comprising:

buffering means for input transmission buffering a video bitstream received from a transmission channel;  
transferring means, coupled to said input transmission buffering means, for multiplexing and transferring the said video bitstream to the multiple video decoders;  
controlling means, coupled to said means for multiplexing and transferring, for controlling the decoding process of each of the multiple video decoders; and  
de-multiplexing means, coupled to said means for controlling the decoding, for controlling the display buffers of each of the multiple video decoders and de-multiplexing the display output of each of the said display buffers.

2. A progressive video decoding system as defined in claim 1 wherein said means for multiplexing and transferring data includes means for identifying coded headers data in the video bitstream and determining the video decoders in which the bitstream is to be transferred to.

3. A progressive video decoding system as defined in claim 1 wherein said means for multiplexing and transferring data includes means for storing the said multiplexed bitstream into input multiplex buffers that are coupled to each of the said video decoders

5 4. A progressive video decoding system as defined in claim 3 wherein said bitstream storing includes means for determining when a said bitstream containing a group of pictures had been received.

5. A progressive video decoding system as defined in claim 2 and 3 wherein said determining includes a micro-controller.

10 6. A progressive video decoding system as defined in claim 1 wherein controlling the decoding process includes decoding means for reconstructing pictures by each of the said multiple video decoders.

15 7. A progressive video decoding system as defined in claim 1 wherein controlling the decoding process includes determining means for the starting and stopping the decoding process of each of the said multiple video decoders.

8. A progressive video decoding system as defined in claim 1 wherein controlling the display buffers of each of the said multiple video decoders includes means for transferring reconstructed pictures by the said multiple decoders to the display buffers and storing the reconstructed pictures into the display buffers.

20 9. A progressive video decoding system as defined in claim 1 wherein de-multiplexing the display output includes means for display controlling of each of the said multiple video decoders display buffers.

25 10. A progressive video decoding system as defined in claim 9 wherein display controlling includes means for determining the start and stop of storing process into the display buffer and the start and stop process of transferring to the display output device.

11. A process of pipeline decoding a video bitstream comprising steps of:

30 receiving a video bitstream by each of the said multiple video decoders into the said input multiplexed buffers;

pipeline decoding by each of the said multiple video decoders using the bitstream data from the said input multiplexed buffers;

35 reconstruction of pictures by each of the said multiple video decoders and storing the said reconstructed pictures into the display buffers coupled to each of the said multiple video decoders; and

controlling the transfer of reconstructed pictures from the display buffers to the display output.

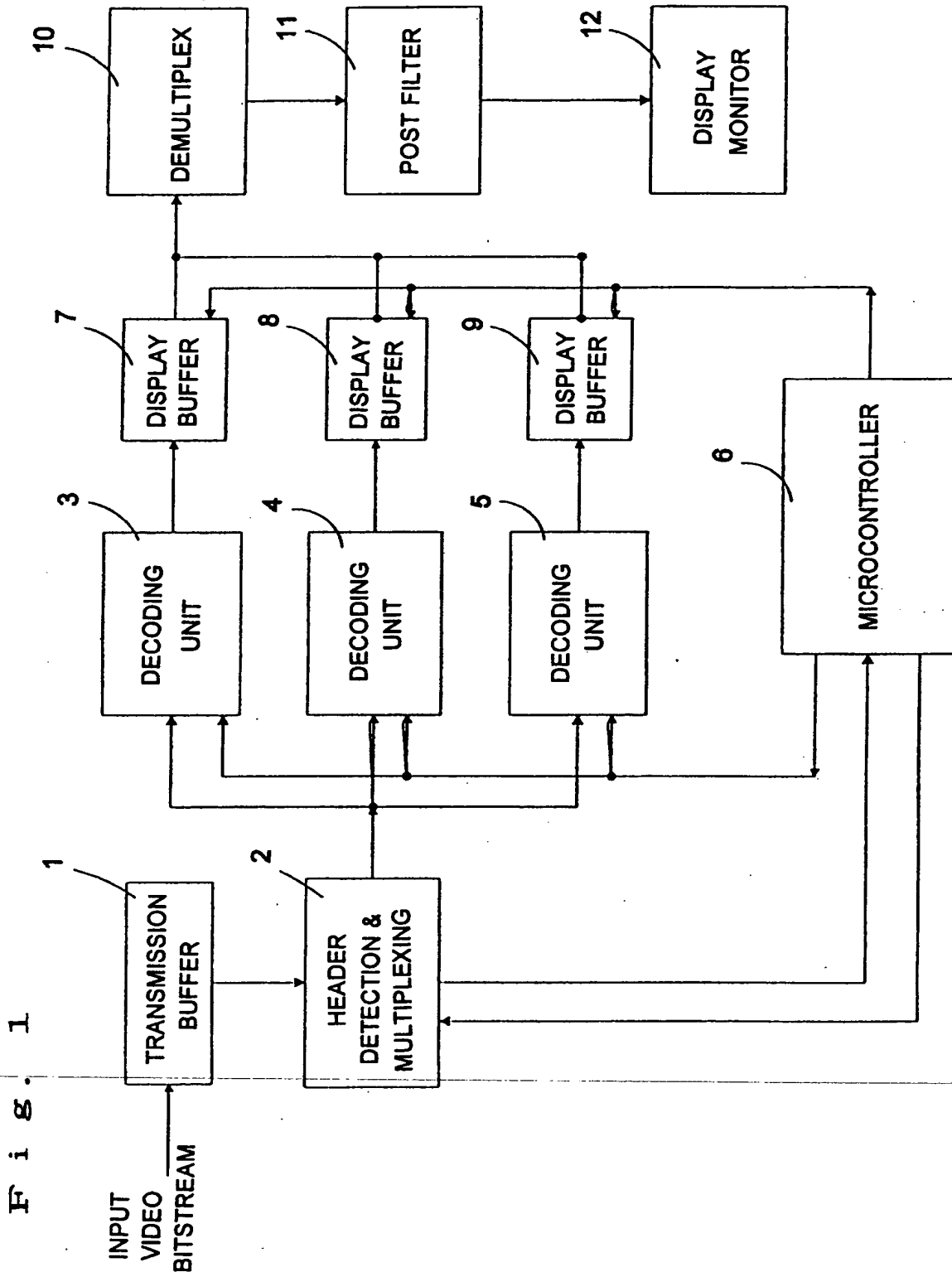


Fig. 2

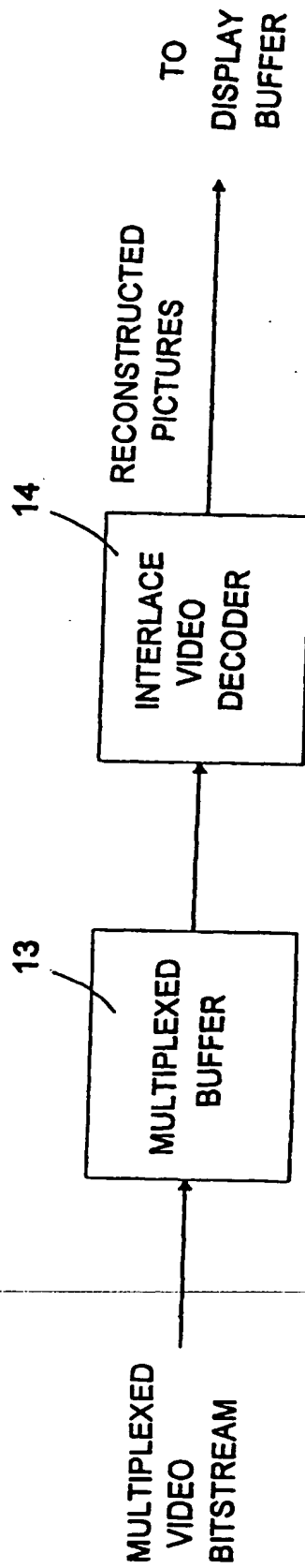


Fig. 3

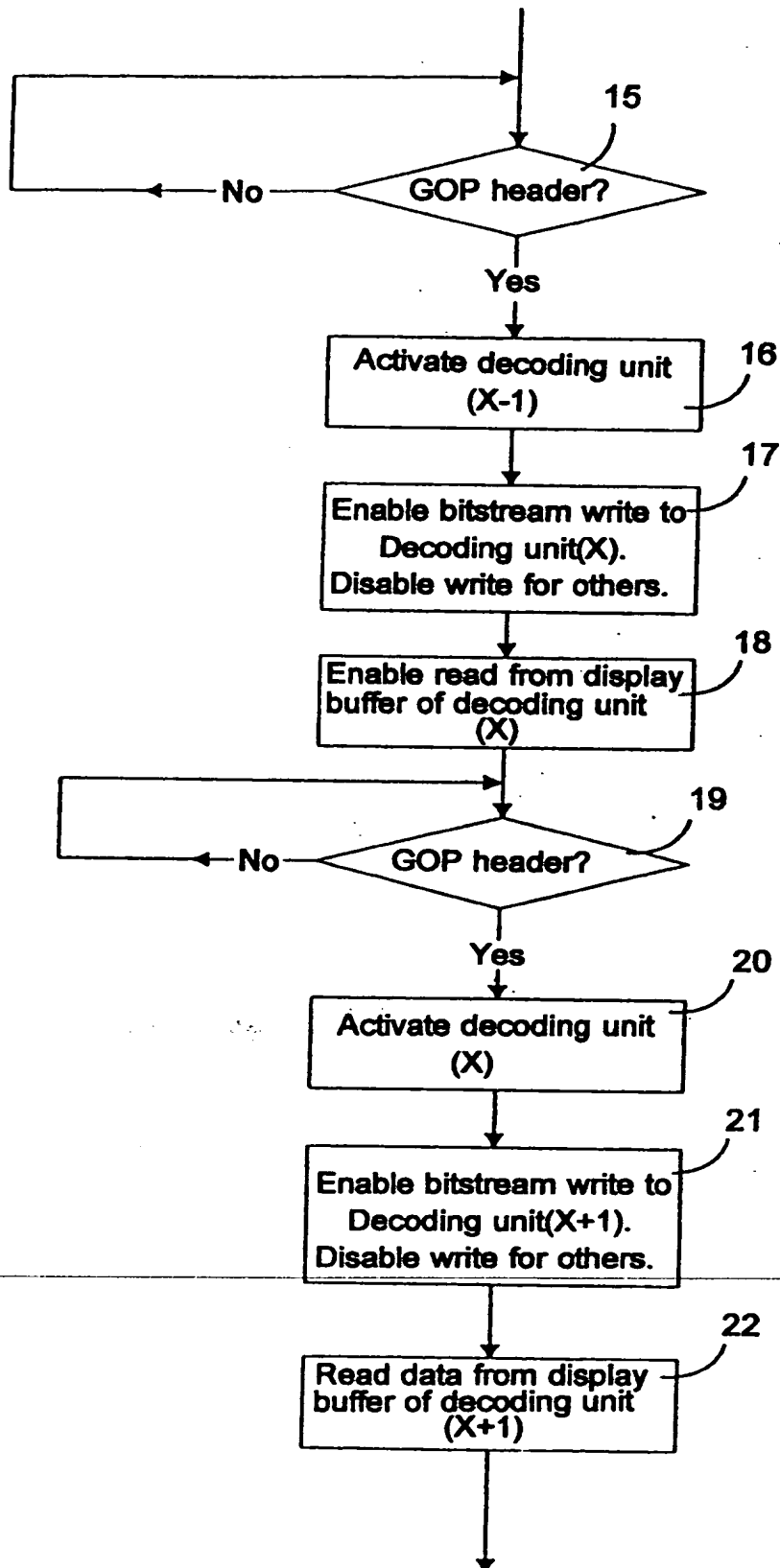
PICTURE TYPE	I	B	B	P	B	B	P	B	P	B	B	I	B	B	P	
PICTURE ORDER	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Fig. 4

PICTURE TYPE	I	P	B	B	P	B	B	P	B	B	I	B	B	P	B	B
PICTURE ORDER	0	3	1	2	6	4	5	9	7	8	12	10	11	15	13	14



Fig. 5



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